Physics 1C, Summer Session I, 2011
Final Exam

Instructions: Do any 8 problems. Please do all work on separate sheets of paper, and hand in everything you want to be graded. Clearly mark the problems that you want graded, and box the answers.

Problem 1: A mass on a spring oscillates with an amplitude A. What is its displacement from the equilibrium position, in terms of A, when the kinetic energy is equal to twice the potential energy?

Problem 2: A string with mass per unit length of 0.010 kg / m is 0.5 meters long and tied down on both ends. Tension is applied to the string.

(a) What should the tension be to achieve a fundamental frequency of 440hz?

(b) If this amount of tension is applied, what is the wave speed in the string?

Problem 3: A dolphin is swimming towards an underwater cliff at a speed of 5 m/s. The dolphin emits an ultrasound wave with a frequency of 100 kHz. When the echo returns from the cliff and interferes with the sound from the source, beats are produced. What is the beat frequency? Take the speed of sound in water to be 1500 m/s.

Problem 4: A red laser (wavelength of 650nm in vacuum) is used to send a signal through a fiber-optic cable. The material of the cable has an index of refraction of 1.58.

(a) What is the frequency of the laser, in THz?

(b) What is the wavelength of the laser light in the cable?

(c) If a signal has to travel through 1km of cable, how much time does it take between when it is sent and when it arrives?

Problem 5: An object is placed 10cm in front of a divergent lens with a focal length of -15cm. A convergent lens with a focal length of 20cm is then placed 30cm behind the divergent lens.

(a) Draw a ray diagram, showing where the final image forms.

(b) Calculate the exact location of the final image (give the distance from the convergent lens, and specify if the image is in front or behind this lens).

Problem 6: A sound wave with a frequency of 120 *hz* is incident on a wall that reflects sound. The direction of travel of the sound wave is perpendicular to the wall. Since the speed of light in the wall is higher than in air, the wave does not undergo a phase shift upon reflection. At what distances from the wall do the incident wave and the echo interfere constructively? At what distances do they interfere destructively?

Problem 7: A spaceship travels to a star 200 light-years away. If the trip takes only 30 years according to the ship's crew, how fast is the spaceship moving (as a fraction of the speed of light)? Neglect the time it takes for the ship to accelerate to that speed.

Problem 8: A proton has a rest energy of $m_P c^2$ = 938MeV. If the proton is to be accelerated to 95% of the speed of light, what voltage must it be accelerated through?

Problem 9: A galaxy is observed through a telescope. A spectral line that has a wavelength of 420*nm* when the source is at rest is found at a wavelength of 600*nm*. Assume that the galaxy is moving either directly towards Earth or directly away from it, not across the field of view. Is it moving towards or away? What is its speed, as a fraction of the speed of light?

Problem 10: Tritium is an isotope of hydrogen consisting of one proton and two neutrons. The tritium nucleus has a rest energy of $m_T c^2$ = 2808.8182 MeV. It undergoes beta decay, turning into helium 3 (two protons and one neutron) and emitting an electron and an electron antineutrino. The helium 3 nucleus has a rest energy of $m_{He3} c^2$ = 2808.2887 MeV, the electron has a rest energy of $m_e c^2$ = 0.5110 MeV, and the antineutrino has a rest energy that is very close to zero.

(a) What is the maximum kinetic energy that the emitted electron could have, in keV?

(b) How fast would the electron emitted with maximum possible kinetic energy be moving, as a fraction of the speed of light?

(c) Is it possible to emit the electron with zero kinetic energy? Explain.